

# **Active and Passive Multi-Functional Filtering Circuits Based on Collaborative Techniques**

A Dissertation Submitted for the Degree of Doctor of Philosophy

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August, 2020



# **CERTIFICATE OF ORIGINAL AUTHORSHIP**

I, Jin-Xu Xu declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctoral Degree, in the School of Electrical and Data Engineering, Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution. I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of the requirements for a degree at any other academic institution except as fully acknowledged within the text. This thesis is the result of a Collaborative Doctoral Research Degree program with South China University of Technology.

This research is supported by the Australian Government Research Training Program.

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**Date:** 2020-08-25

## Related Published Works in This Thesis

Since I am in a Collaborative Doctoral Research Degree program with South China University of Technology (SCUT), this thesis includes both the works during my PhD period in UTS and SCUT. The results presented in this thesis discuss both the published works during my PhD candidature in UTS and SCUT, which are detailed as follows.

- [1]. J.-X. Xu, H.-Y. Li, X. Y. Zhang, Y. Yang, Q. Xue and E. Dutkiewicz, “Compact dual-channel balanced filter and balun filter based on quad-mode dielectric resonator,” *IEEE Trans. Microw. Theory Tech.*, vol. 65, no. 11, pp. 4636-4644, Feb. 2019.
- [2]. J.-X. Xu, X. Y. Zhang, H.-Y. Li, Y. Yang, E. Dutkiewicz and Q. Xue, “Ultra-compact multi-channel bandpass filter based on tri-mode dielectric resonator for 5G massive MIMO antenna system,” *IEEE Trans. Microw. Theory Tech.*, vol. 68, no. 5, pp. 1668-1677, May 2020.
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# **Abstract**

In radio frequency front ends, there are lots of active and passive circuits, such as filters, power amplifiers (PAs), switches, couplers and so on. Generally, they are cascaded in wireless systems, which suffer from the large size, high loss, or efficiency degradation due to impedance mismatching. To solve these problems, novel methods for collaborative designs of multiple circuits are proposed, and overall performance is improved by the complementation of different circuits. Design methods for fusion of multiple circuits are also proposed by constructing one circuit function into another circuit, which can simplify the structures to reduce the size and loss. Lots of active and passive multi-functional filtering circuits are proposed, including the following three sections:

1. To improve overall efficiency of the PA, switch, and filter, integration of filters and active circuits are conducted. To reduce the total loss and improve isolation of the switch and filter, coupling control method is proposed to fuse the functions of filter and switch. To avoid efficiency degradation by impedance mismatching, the collaborative design of a class-F PA and a high-selectivity filter is presented.

2. To reduce the loss and size, filters are integrated with other passive circuits. The functions of a balun circuit and a rat-race coupler are fused to a filter to realize the miniaturized filtering balun and filtering rat-race coupler, respectively. By using a common dual-mode resonator, a compact LTCC diplexer with controllable frequencies and bandwidths is designed.

3. For high integration, dual-/multi-channel filtering circuits are proposed. Based on a quad-mode dielectric resonator, two filters are integrated as one dual-channel filter, and then collaborative-designed with a two-input two-output Doherty PA for high integration and high efficiency. For further integration, multi-channel filters and dual-channel balanced/balun filters are also proposed.

In this thesis, design methods and working mechanisms of proposed multi-functional filtering circuits are detailed. Measured results are given to show the validity of the proposed designs. As compared to reported designs or products from

some international companies, the proposed designs show advantages of miniaturization or low power consumption, which are useful in wireless applications.

**Keywords:** Active multi-functional filtering circuit, filtering switch, filtering power amplifier, passive multi-functional filtering circuit, multi-channel filtering circuit, collaborative-design



# Acknowledgement

I am very thankful to Dr. Yang Yang and Prof. Eryk Dutkiewicz who are my supervisors during the Collaborative Doctoral Research Degree Program in University of Technology, Sydney (UTS). They provide me with a good learning platform, enrich my research experience and also improve my PhD thesis. Especially for Dr. Yang Yang who also helps me a lot in my daily life.

I would like to express my sincere gratitude to my supervisor Prof. Xiu Yin Zhang in South China University of Technology (SCUT). Prof. Zhang is a knowledgeable and experienced supervisor. Under his supervision and support, I have a good accumulation of professional research knowledge and have obtained a great improvement in practical ability, and also have successfully completed my research subject and published several international-referred journal papers. Moreover, I would like to thank Prof. Zhang for recommending me to study in UTS. He definitely makes a crucial role in my research achievements and will also make a significant influence on my future life.

I am grateful to Prof. Quan Xue for offering me the opportunity of internship before my doctoral admission so that I can accumulate the scientific research background and experience, which is of great help for my PhD study.

I give my sincere acknowledgement to all teachers who helped me a lot during my PhD study, including Prof. Xiaolan Zhao, Prof. Binjie Hu, Prof. Yongmei Pan, Prof. Huifen Huang, Dr. Yang Jun, Dr. Honglin Zhang and so on. Their joint efforts have created a good academic atmosphere for the lab. Particularly, I thank Prof. Xiaolan Zhao for her care and help in my scientific research and daily life.

I would like to thank all the students who studied with me together in UTS, for making me feel in a comfortable and harmonious scientific research environment abroad. I also would like to express my thanks to all my colleagues in SCUT. I have benefited a lot from learning and discussing with them.

In addition, I would like to express my special thanks to my family as well as my

girlfriend, Ms. Huiyang Li, for their care, encouragement, and support all the time.

Finally, I would like to thank the experts and teachers who provided their suggestions on my thesis revision, which will definitely improve the quality of my thesis and make me have a deeper understanding of my thesis work.

Jinxu Xu

Aug. 2020

# Contents

<b>Abstract</b> .....	i
Acknowledgement .....	iii
Contents .....	v
List of Figures.....	viii
List of Tables.....	xix
Chapter 1 Introduction .....	1
1.1 Research Background and Significance .....	1
1.2 Introduction of Multi-Functional Filtering Circuits.....	3
1.2.1 Active Multi-Functional Filtering Circuits .....	4
1.2.1 Passive Multi-Functional Filtering Circuits.....	12
1.3 Thesis Motivation and Organization.....	22
Chapter 2 Active Multi-Functional Filtering Circuits.....	25
2.1 Introduction.....	25
2.2 Proposed Methods for Co-Design and Function-Fusion of Filters and Active Circuits .....	25
2.3 Single- and Dual-Band LTCC Filtering Switch.....	28
2.3.1 Coupling Matrix Analysis for the Filtering Switch in the ON- and OFF-States .....	30
2.3.2 Single-Band LTCC Filtering Switch.....	32
2.3.3 Dual-Band LTCC Filtering Switch .....	40
2.3.4 Comparison.....	47
2.4 SPST and SPDT Filtering Switches Based on $TE_{11\delta}$ -Mode Dielectric Resonators.....	49
2.4.1 Analysis of Two Types of Coupling Schemes .....	50
2.4.2 DR-Based SPST Filtering Switch.....	55
2.4.3 Two-Cavity DR-Based SPDT Filtering Switch .....	60
2.4.4 Three-Cavity DR-Based SPDT Filtering Switch.....	63

2.4.5 Comparison.....	71
2.5 High-Efficiency Filter-Integrated Class-F Power Amplifier Based on Dielectric Resonator .....	73
2.5.1 Analysis of DR Filter with Impedance Conversion .....	74
2.5.2 Filter-Integrated Class-F PA Design .....	76
2.5.3 Experiment and Comparison .....	78
2.6 Conclusions.....	81
Chapter 3 Passive Multi-Functional Filtering Circuits .....	83
3.1 Introduction.....	83
3.2 Proposed Methods for Co-Design and Function-Fusion of Filters and Other Passive Circuits.....	83
3.3 Compact LTCC Balun With Bandpass Response Based on Marchand Balun.....	87
3.3.1 Analysis of the LTCC Balun Filter .....	88
3.3.2 Circuit Design, Experiment and Comparison .....	90
3.4 Compact High-Isolation LTCC Diplexer Using Common Stub-Loaded Resonator with Controllable Frequencies and Bandwidths .....	94
3.4.1 Analysis of LTCC Diplexer .....	96
3.4.2 Design of LTCC Diplexer .....	104
3.4.3 Experiment and Comparison .....	108
3.5 Filtering Rat-Race Coupler Based on Quad-Mode Dielectric Resonator .....	112
3.5.1 Filtering Rat-Race Coupler Based on Quad-Mode Rectangular DR .....	113
3.5.2 Filtering Rat-Race Coupler Based on Quad-Mode Cylindrical DR .....	128
3.5.3 Comparison.....	133
3.6 Conclusions.....	134
Chapter 4 Dual-/Multi-Channel Filtering Circuits.....	135

4.1 Introduction.....	135
4.2 Proposed Methods for Dual-/Multi-Channel Filter and Filtering Circuits .....	136
4.3 Dual-Channel Filter and Its Co-design with a Two-Input Two-Output Doherty Power Amplifier.....	138
4.3.1 Dual-Channel Filter Design .....	139
4.3.2 Co-Design of Dual-Channel DR Filter and Two-Input Two-Output Doherty Power Amplifier.....	149
4.4 Multi-Channel DR Filter.....	154
4.4.1 Analysis of Triple-Mode Dielectric Resonator .....	155
4.4.2 Multi-Channel DR Filter Design .....	157
4.4.3 Experiment and Comparison .....	167
4.5 Compact Dual-Channel Balanced Filter and Balun Filter Based on Quad- Mode Dielectric Resonator .....	170
4.5.1 Analysis of the Quad-Mode DR.....	170
4.5.2 Dual-Channel Balanced Filter .....	174
4.5.3 Dual-Channel Balun Filter.....	184
4.5.4 Comparison.....	187
4.6 Conclusions.....	187
Chapter 5 Conclusions and Future Works.....	189
5.1 Conclusions.....	189
5.2 Future Works.....	190
Reference .....	193
Publications.....	209
Journal Papers .....	209
Conference Papers .....	210
Awards .....	211

# List of Figures

Figure 1.1. Schematic of a wireless system. ....	2
Figure 1.2. (a) Photograph of a microwave filter in [2]; (b) 3-D structure and photograph of a LTCC filter in [3].....	3
Figure 1.3. Photographs of dielectric resonator filters in [5].....	4
Figure 1.4. A filtering switch based on a switchable delay line [16] (a) Structure; (b) With Chebyshev filtering responses; (c) With quasi-elliptic filtering responses....	5
Figure 1.5. A filtering switch using switchable connect line in [17] (a) Circuit structure; (b) Simulated and measured results. ....	5
Figure 1.6. Wide stopband filtering switch [18] (a) Structure; (b) ON-state responses; (b) OFF-state responses.....	6
Figure 1.7. Dual-band filtering switch using stub-loaded resonators [21] (a) Circuit structure; (b) Lower passband is turned on; (c) Upper passband is turned on.....	6
Figure 1.8. SPDT filtering switch in [22] (a) Circuit structure; (b) Simulated and measured results.....	7
Figure 1.9. LTCC filtering switch in [24] (a) Schematic; (b) Photograph of the fabricated circuit; (c) Measured results. ....	8
Figure 1.10. A class-F power amplifier based on CMRC [25] (a) Schematic; (b) Structure and simulated results of the CMRC; (c) Measured results of the power amplifier. ....	9
Figure 1.11. A class-E power amplifier in [27] (a) Schematic; (b) Simulated and measured drain efficiencies.....	10
Figure 1.12. Co-design of filter and power amplifier in [28]. ....	11
Figure 1.13. A filtering power amplifier in [29] (a) Schematic; (b) Output power against frequency; (c) Output power, gain and efficiency against input power....	11
Figure 1.14. Filtering power amplifier based on coaxial resonators in [30] (a) Schematic; (b) Simulated and measured results. ....	12
Figure 1.15. A filtering power divider in [34] (a) Structure; (b) Simulated and	

measured results.....	13
Figure 1.16. Structure, simulated and measured results of the wide stopband filtering power amplifier [35]. ....	13
Figure 1.17. Reconfigurable single- and dual-band filtering power divider [38] (a) Photograph of the fabricated circuit; (b) S parameters when it work in dual-band operation. ....	14
Figure 1.18. Tunable filtering power divider with constant absolute bandwidth in [39] (a) Circuit structure; (b) Topology; (c) Simulated and measured $S_{21}$ & $S_{31}$ ..	15
Figure 1.19. Filtering balun based on hybrid resonators [42] (a) Equivalent circuit of the hybrid resonator; (b) Structure of the hybrid resonator; (c) Photograph of the fabricated filtering balun; (d) Measured S parameters; (e) Measured phase and amplitude imbalances. ....	16
Figure 1.20. SIW-based filtering balun [44] (a) Structure; (b) Experimental results. ....	16
Figure 1.21. LTCC filtering balun in [45] (a) Structure; (b) S parameters; (c) Amplitude balanced and phase difference. ....	17
Figure 1.22. A balanced filter in [48] (a) Photograph; (b) Differential-mode responses; (c) Common-mode responses.....	18
Figure 1.23. Balanced filters using stub-loaded resonators [49] (a) Dual-band design; (b) Tri-band design. ....	18
Figure 1.24. Balanced filter based on TE <sub>118</sub> mode DRs in [51] (a) Circuit structure; (b) Simulated and measured results. ....	19
Figure 1.25. Filtering rat-race coupler in [54] (a) Photograph; (b) $S_{11}$ , $S_{21}$ & $S_{31}$ ; (c) $S_{44}$ , $S_{34}$ & $S_{24}$ . ....	20
Figure 1.26. Tunable filtering rat-race coupler based on half-mode SIW cavities [56] (a) photograph; (b) $S_{44}$ , $S_{24}$ , $S_{34}$ & $S_{13}$ ; (c) $S_{11}$ , $S_{21}$ , $S_{31}$ & $S_{41}$ .....	20
Figure 1.27. Filtering coupler based on DRs in [59] (a) Photograph of the fabricated circuit; (b) Simulated and measured results.....	21
Figure 2.1. Schematic of the cascaded power amplifier, switch and filter. ....	25

Figure 2.2. Schematic of the proposed function-fusion method of the filter and switch.....	27
Figure 2.3. Schematic of the co-design method of filter and power amplifier. ....	28
Figure 2.4. Calculated responses of the coupling matrices with different (a) $M_{S1}$ ; (b) $M_{12}$ ; (c) $M_{S1}$ and $M_{2L}$ ; (d) $M_{S1}$ and $M_{12}$ .....	31
Figure 2.5. Single-band LTCC filtering switch (a) Schematic; (b) 3-D structure.	33
Figure 2.6. (a) Simulated ON-state responses of the LTCC filtering Switches; (b) Equivalent circuit in the ON-state with asymmetric feeding structure; (c) Simulated results of a feeding line and a resonator: case 1: $\theta_1 = 80^\circ$ , $\theta_2 = 50^\circ$ , $\theta_3 = 50^\circ$ ; case 2: $\theta_1 = 80^\circ$ , $\theta_2 = 40^\circ$ , $\theta_3 = 50^\circ$ ; case 3: $\theta_1 = 90^\circ$ , $\theta_2 = 50^\circ$ , $\theta_3 = 50^\circ$ ; case 4: $\theta_1 = 80^\circ$ , $\theta_2 = 50^\circ$ , $\theta_3 = 60^\circ$ , unit: degree with respect to $f_0$ . ....	34
Figure 2.7. Coupling structure between two coupled resonators and its voltage distribution.....	36
Figure 2.8. Simplified OFF-state schematic of the feeding structure and the voltage distribution.....	38
Figure 2.9. 3-D view of the proposed LTCC filtering switch with test PCB board. ....	38
Figure 2.10. Simulated and measured results of the single-band LTCC filtering switch; (a) ON-state; (b) OFF-state. ....	39
Figure 2.11. Dual-band LTCC filtering switch; (a) Schematic; (b) 3-D structure.	41
Figure 2.12. (a) The structure of the stub-loaded resonator; (b) Even-mode equivalent circuit; (c) Odd-mode equivalent circuit; (d) voltage distribution of the even-mode circuit. ....	42
Figure 2.13. Simulated responses of the dual-band filtering switch (a) with different upper passband bandwidths; (b) with different upper passband frequencies. ....	44
Figure 2.14. (a) The equivalent OFF-state schematic; (b) The voltage distribution at $f_{\text{odd}}$ ; (c) The voltage distribution at $f_{\text{even}}$ . ....	45
Figure 2.15. Simulated and measured results of the dual-band LTCC filtering switch; (a) ON-state; (b) OFF-state.....	47



Figure 2.16. 3-D view of a typical rectangular DR. ....	51
Figure 2.17. EM field distributions of the $TE_{11\delta}$ -mode rectangular DR (a) Vector of E-field in $x$ - $y$ plane; (b) Magnitude of E-field in $x$ - $y$ plane; (c) Vector of H-field in the plane of $z = L/2$ ; (d) Magnitude of H-field in the plane of $z = L/2$ . ....	52
Figure 2.18. (a) The structure of the metal probe in the metal cavity; (b) E- and H-fields of the metal probe with two short-circuited branches. ....	53
Figure 2.19. The proposed coupling schemes (a) Type I; (b) Type II. ....	54
Figure 2.20. EM fields for the Type I coupling scheme; (a) H-field; (b) E-field. ....	55
Figure 2.21. 3-D view of the fourth-order DR filtering switch. ....	56
Figure 2.22. Equivalent circuits of the feeding in the (a) OFF-state; (b) ON-state. ....	57
Figure 2.23. Photograph of the fabricated DR-based SPST filtering switch. ....	58
Figure 2.24. Simulated and measured results (a) In the ON-state; (b) In the OFF-state. ....	59
Figure 2.25. Two-cavity DR-based SPDT filtering switch (a) 3-D structure; (b) Topology. ....	60
Figure 2.26. Photograph of the fabricated two-cavity DR-based SPDT filtering switch. ....	62
Figure 2.27. Simulated and measured results (a) In State 1; (b) In State 2. ....	63
Figure 2.28. Structure of the SPDT DR filtering switch, (a) 3-D view; (b) Topology. ....	64
Figure 2.29. (a) The circuit structure of Filter 1; (b) Topology of Filter 1. ....	65
Figure 2.30. Simulated $S_{21}$ of Filter 1 (a) with different $TZ_2$ ; (b) with different $TZ_1$ . ....	67
Figure 2.31. Circuit structure of Filter 2. ....	68
Figure 2.32. (a) Two types coupling between probe and DR; (b) Topology of Filter 2 with the phase shift characteristic. ....	69
Figure 2.33. Simulated $S_{21}$ of Filter 2 (a) with different $TZ_2$ ; (b) with different $TZ_1$ . ....	69

Figure 2.34. Photograph of the fabricated three-cavity DR-based SPDT filtering switch.....	70
Figure 2.35. Simulated and measured results (a) State 1; (b) State 2. ....	71
Figure 2.36. Structure of the DR filter (a) front view; (b) top view; (c) topology.....	75
Figure 2.37. Schematic of the presented filter-integrated class-F PA.....	77
Figure 2.38. Synthesized and simulated results of the DR matching filter.....	78
Figure 2.39. Photograph of the filter-integrated class-F PA. ....	79
Figure 2.40. (a) Harmonic impedance; (b) voltage and current waveform at the drain. ....	79
Figure 2.41. Measured S-parameters of the presented filter-integrated class-F PA. ....	80
Figure 2.42. (a) Measured $P_{out}$ and PAE versus frequency; (b) $P_{out}$ over a wide frequency range.....	80
Figure 2.43. Measured output power $P_{out}$ , gain, PAE and drain efficiency. ....	80
Figure 3.1. Schematic of the proposed function-fusion method for the filter and balun circuit. ....	84
Figure 3.2. Schematic of the propose diplexer.....	85
Figure 3.3. Schematic of the proposed function-fusion method of filter and rat-race coupler.....	86
Figure 3.4. 3-dimensional structure of the proposed LTCC BPF.....	88
Figure 3.5. (a) Conventional Marchand balun; (b) Even-mode equivalent circuit; (c) Odd-mode equivalent circuit. ....	89
Figure 3.6. Structure of balun with filtering responses.....	89
Figure 3.7. (a) Proposed topology of the filteirng balun; (c) Topology of the network from port 1 to port 2.....	90
Figure 3.8. Detail layouts of the proposed LTCC balun filter. ....	92
Figure 3.9. (a) Photograph of the fabricated circuit with test PCB-board; (b) Synthesis, simulated and measured $S_{11}$ , $S_{21}$ & $S_{31}$ ; (c) Simulated and measured phase difference. ....	93

Figure 3.10. Schematic of the presented LTCC diplexer. ....	96
Figure 3.11. (a) Structure of the common resonator; (b) Odd-mode equivalent circuit; (c) Even-mode equivalent circuit. ....	97
Figure 3.12. The transmission paths on the common resonator. ....	98
Figure 3.13. Calculated $S_{21}$ of Path A and Path B under weak coupling. ....	99
Figure 3.14. Schematic of the higher channel filter. ....	100
Figure 3.15. Simulated result of the higher channel filter. ....	100
Figure 3.16. (a) The coupling structure for generating a transmission zero at $f_H$ ; (b) simulated responses of the coupling structure. ....	101
Figure 3.17. (a) Schematic of the lower channel filter; (b) voltage distribution of the common resonator at $f_H$ . ....	102
Figure 3.18. Simulated responses of the lower channel filter. ....	103
Figure 3.19. Simulated $S_{23}$ of the presented diplexer. ....	104
Figure 3.20. 3-D structure of the presented LTCC diplexer. ....	105
Figure 3.21. (a) LTCC structure of the coupling region from layer 3 to layer 7; (b) Equivalent circuit of the coupling region. ....	107
Figure 3.22. Simulated results of the LTCC diplexer (a) with different lower passband bandwidths; (b) with different passband frequencies. ....	108
Figure 3.22. Layouts of the proposed LTCC diplexer. ....	109
Figure 3.24. (a) 3-D view of the LTCC diplexer with test PCB board; (b) Photograph of the fabricated LTCC diplexer. ....	110
Figure 3.25. Simulated and measured results of the LTCC diplexer. ....	110
Figure 3.26. Quad-mode rectangular DR (a) 3-D structure; (b) Resonant frequencies versus $h$ . ....	114
Figure 3.27. EM-field distributions of the quad-mode DR at (a) M2 pair; (b) M3 pair. ....	115
Figure 3.28. The quad-mode rectangular DR with four tuning probes. ....	115
Figure 3.29. (a) Schematic of a rat-race coupler; (b) Schematic of an in-phase power divider; (c) Schematic of an out-of-phase power divider. ....	116

Figure 3.30. 3-D structure of the in-phase filtering power divider. ....	117
Figure 3.31. Top-view of EM-field distributions of the DR and feeding probes at (a) M2' mode; (b) M2" mode; (c) M3' mode; (d) M3" mode. ....	117
Figure 3.32. (a) Topology of the in-phase power divider; (b) Topology of the half in-phase power divider. ....	119
Figure 3.33. Extracted $Q_{e1}$ and $Q_{e2}$ (a) against $L_1$ ; (b) against $g_1$ . ....	120
Figure 3.34. (a) Theoretical and simulated results of the in-phase power divider; (b) Simulated phase difference between $S_{21}$ and $S_{31}$ . ....	121
Figure 3.35. 3-D structure of the out-of-phase filtering power divider. ....	122
Figure 3.36. Top view of EM-field distributions of the DR and feeding probes in the out-of-phase power divider at (a) M2'; (b) M2"; (c) M3'; (d) M3".....	122
Figure 3.37. Topology of the out-of-phase filtering power divider. ....	122
Figure 3.38. Simulated responses of the out-of-phase filtering power divider (a) $S_{24}$ , $S_{34}$ & $S_{44}$ ; (b) Phase difference between two output ports. ....	123
Figure 3.39. 3-D structure of the filtering rat-race coupler using rectangular DR. ....	123
Figure 3.40. Simulated $S_{22}$ , $S_{33}$ and $S_{41}$ of the rat-race coupler. ....	124
Figure 3.41. Simulated $S_{11}$ and $S_{21}$ (a) versus $h$ ; (b) versus $t$ . ....	125
Figure 3.42. Photograph of the fabricated rectangular-DR-based filtering rat-race coupler. ....	125
Figure 3.43. Simulated and measured results under the in-phase operation. (a) $S_{11}$ , $S_{21}$ & $S_{31}$ ; (b) Phase difference between the two output ports. ....	126
Figure 3.44. Simulated and measured results under the out-of-phase operation. (a) $S_{44}$ , $S_{24}$ & $S_{34}$ ; (b) Phase difference between the two output ports. ....	127
Figure 3.45. Simulated and measured $S_{22}$ , $S_{33}$ & $S_{41}$ . ....	128
Figure. 46. 3-D structure of the filtering rat-race coupler using cylindrical DR. ....	129
Figure 3.47. E-field distribution of the feeding probes and DR at (a) $HEH'_{11}$ ; (b) $HEH''_{11}$ ; (c) $HEE'_{11}$ ; (d) $HEE''_{11}$ . ....	130
Figure 3.48. Photograph of the filtering rat-race coupler based on cylindrical DR. ....	

.....	131
Figure 3.49. Simulated and measured results under the in-phase operation. (a) $S_{11}$ , $S_{21}$ & $S_{31}$ ; (b) Phase difference between the two output ports. ....	131
Figure 3.50. Topology from port 1 to port 2 (or port 3).....	131
Figure 3.51. Simulated and measured results under the out-of-phase operation. (a) $S_{44}$ , $S_{24}$ & $S_{34}$ ; (b) Phase difference between the two output ports.....	132
Figure 3.52. Simulated and measured $S_{22}$ , $S_{33}$ & $S_{41}$ .....	132
Figure 4.2. Schematic of the proposed dual-channel filter. ....	136
Figure 4.3. Schematic of the proposed multi-channel filter.....	137
Figure 4.4. (a) Dual-channel balanced filter; (b) Dual-channel balun filter. ....	137
Figure 4.5. 3-D structure of the dual-channel DR filter.....	140
Figure 4.6. (a) 3-D structure of the cylindrical DR; (b) Resonant frequencies of the modes versus $H$ . ....	141
Figure 4.7. E-field distribution of the DR (a) $HEH_{11}$ pair; (b) $HEE_{11}$ pair. ....	141
Figure 4.8. Structure of one channel filter (a) 3-D configuration; (b) top view. ....	142
Figure 4.9. E-field distribution of the two feeding probes and DR (a) $HEH_{11}^1$ mode; (b) $HEH_{11}^2$ mode; (c) $HEE_{11}^1$ mode; (d) $HEE_{11}^2$ mode. ....	142
Figure 4.10. Simulated $S_{21}$ of the single-channel filter under weak coupling. ...	143
Figure 4.11. Topology of the single-channel filter.....	143
Figure 4.12. E-field distributions of the filter at (a) $HEH_{11}^1$ mode; (b) $HEE_{11}^1$ mode. ....	144
Figure 4.13. Simulated $Q_{e1}$ and $Q_{e2}$ (a) against $L_1$ ; (b) against $g_1$ . ....	145
Figure 4.14. Simulated results of the single-channel DR filter.....	145
Figure 4.15. (a) E-field distribution of the DR at TME mode; (b) The DR with tuning probes.....	146
Figure 4.16. Simulated responses of the lower channel filter. ....	147
Figure 4.17. Simulated isolation between two channel filters. ....	147
Figure 4.19. Simulated and measured results of the dual-channel filter (a) $S_{11}$ , $S_{21}$ , $S_{33}$ and $S_{43}$ ; (b) $S_{13}$ , $S_{14}$ , $S_{23}$ & $S_{24}$ .....	149

Figure 4.20. Simplified schematic of the compact $2 \times 2$ DPA. ....	150
Figure 4.21. The impedance conversion dual-channel filter with different source impedances.....	151
Figure. 4.22. Photograph of the fabricated filter-integrated $2 \times 2$ DPA. ....	152
Figure. 4.23. Small-signal responses of the filter-integrated $2 \times 2$ DPA. ....	152
Figure 4.24. (a) Simulated and measured total drain efficiency and gain versus total output power at 3.53 GHz. (b) Output power versus frequency. ....	153
Figure 4.25. (a) Output power and output power imbalance versus input power; (b) DC currents for the peaking amplifiers.....	154
Figure 4.26. 3-D structure of the tri-mode dielectric resonator. ....	155
Figure 4.27. Resonant frequencies of the DR versus $a$ . ( $b$ and $c$ are kept the same as $a$ when $a$ is changed.) .....	156
Figure 4.28. EM-field distribution of the DR at (a) $TE_{101}$ mode; (b) $TE_{011}$ mode; (c) $TM_{110}$ mode.....	157
Figure 4.29. 3-D structure of the DR with two feeding probes. ....	158
Figure 4.30. EM-field distributions of the DR with two feeding probes at (a) $TE_{101}$ mode; (b) $TE_{011}$ mode; (c) $TM_{110}$ mode. ....	159
Figure 4.31. (a) 3-D structure of the DR with six feeding probes. (b) Simulated results of the DR with six feeding probes under weak coupling. ....	160
Figure 4.33. Topology of one transmission path of the 12-channel DR filter. ...	162
Figure 4.34. (a) $k_{12, \text{ext}}$ against $L_1$ ; (b) $Q_{e, \text{ext}}$ against $L_2$ . ....	163
Figure 4.35. Simulated results of the 12-channel BPF (a) $S_{11}$ and $S_{21}$ ; (b) Transmission coefficient between channels.....	163
Figure 4.36. Simulated $S_{31}$ of the proposed 12-channel BPF (a) with different values of $L_1$ ; (b) with different values of $L_2$ . ....	164
Figure 4.37. Simulated results of the second-order multi-channel filter with different bandwidth (a) $S_{21}$ ; (b) $S_{31}$ . ....	164
Figure 4.38. 3-D structure of a twenty seven-channel filter with third-order filtering responses. ....	165

Figure 4.39. Simulated results (a) $S_{11}$ and $S_{21}$ ; (b) Transmission coefficient between channels. ....	166
Figure 4.40. 3-D structure of the multi-channel filter second-, third- and fourth-order filtering responses.....	167
Figure 4.41. Simulated results of BPF with different orders in one multi-channel filter (a) Second-order; (b) Third-order; (c) Fourth-order.....	167
Figure 4.42. Photograph of the fabricated twelve-channel BPF. ....	168
Figure 4.43. Simulated and measured results of the 12-channel DR filter (a) $S_{11}$ and $S_{21}$ ; (b) Transmission coefficient between different channels.....	169
Figure 4.44. 3-D structure of the cylindrical quad-mode DR in a metallic cavity. ....	171
Figure 4.45. Resonant frequencies of the DR with (a) different $h$ ; (b) different $d$ . ....	172
Figure 4.46. EM-field distributions of the quad-mode DR at (a) M2 pair; (b) M3 pair. ....	173
Figure 4.47. (a) Side view of E-field at M2 and M3 modes; (b) DR with four tuning probes at $z = h / 2$ plane; (c) Resonant frequencies of M2 and M3 pairs against $t_1$ . ....	173
Figure 4.48. 3-D structure of the dual-channel balanced filter. ....	174
Figure 4.49. Structure of the quad-mode DR with two single-end feeding probes. ....	175
Figure 4.50. EM-field distribution of the DR with single-end feeding probes at (a) M2' mode; (b) M2'' mode; (c) M3' mode; (d) M3'' mode. ....	176
Figure 4.51. Simulated $S_{21}$ of the single-end feeding structure under weak coupling. ....	176
Figure 4.52. 3-D structure of the DR with differential feeding probes.....	177
Figure 4.53. EM-field distributions of the quad-mode DR (a) DM excitation at M2' mode; (b) DM excitation at M3' mode; (c) CM excitation at M2' mode; (d) CM excitation at M3' mode.....	177

Figure 4.54. Simulated $S_{21}^{dd}$ and $S_{21}^{cc}$ under weak coupling.....	178
Figure 4.55. Topology of single-channel balanced filter. ....	178
Figure 4.56. (a) Calculated responses of matrix (3) and simulated results of the single-channel balanced filter; (b) Simulated results with different bandwidths.	180
Figure 4.57. Top view of EM-field distributions of DR and the feeding probes.	180
Figure 4.58. Simulated DM isolation between two channels. ....	181
Figure 4.59. Simulated results of the filter with different values of $t$ . ....	181
Figure 4.60. Photograph of the fabricated dual-channel balanced filter. ....	182
Figure 4.61. Simulated and measured results (a) Transmission and reflection coefficient for 2.8 to 4.2 GHz; (b) DM responses in a wide frequency range and around the passband; (c) DM and CM isolation between two channels.....	183
Figure 4.62. Dual-channel balun filter (a) Schematic; (b) 3-D structure.....	184
Figure 4.63. Photograph of the fabricated dual-channel balun filter. ....	185
Figure 4.64. Simulated and measured results (a) Transmission and reflection coefficient from 2.8 to 4.2 GHz; (b) Transmission and reflection coefficient in a wide frequency range and around the passband; (c) Phase difference and magnitude imbalance; (d) Isolation. ....	186
Figure 5.1. Schematic of an RF front end in IC technology (a) conventional solution; (b) collaborative-design solution.....	192



# List of Tables

Table 2.1 Comparison With LTCC Filters and Switches .....	40
Table 2.2 Comparison With Some Other Filtering Switches.....	48
Table 2.3 Comparison With Some DR Filters, Filtering Switches and Switch Products .....	73
Table 2.4 Comparison of Various Filter-Integrated PAs .....	81
Table 3.1 Comparison With Some Other LTCC Balun Filters .....	94
Table 3.2 Comparison With Some Other Diplexers.....	111
Table 3.3 Comparison With Some Other Filtering Couplers.....	133
Table 4.1 Comparison With Other DR filters .....	149
Table 4.2 Comparison With Some Other Couplers.....	169
Table 4.3 Comparison With Some Other Balanced and Balun Filters.....	187

